Diet of the Lace Monitor Lizard *(Varanus varius)* in south-eastern Australia

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Since *Varanus varius* (the lace monitor or lace goanna) is the second largest terrestrial carnivore indigenous to mainland south-eastern Australia (Weavers 1988), its diet is of some ecological interest. To date, however, there have been no quantitative descriptions of the diet of *V. varius.* Australian varanids are generally considered carnivores which ingest plant material near prey only by accident, although Johnson (1972) has reported that *V. gouldii* in captivity ate a mixture of "pet meat and vegetables". Food items recorded from stomach contents of museum specimens of Australian *Varanus* spp. other than *V. varius* ranged from arthropods and reptile eggs for the smallest species, *V. gilleni,* to arthropods, mammals, birds, lizards, and reptile eggs for larger species such as *V. panoptes, V. tristis, V. gouldii,* or *V. rosenbergi* (varanid diets reviewed by Losos and Green 1988). According to anecdotal accounts, the diet of *V. varius* includes arthropods, reptiles, amphibians, eggs, birds, small mammals and carrion including dead conspecifics (e.g. Broadbent 1910; Gogerley 1922; Hindwood 1926; Worrell 1963; Bustard 1970; Vestjens 1973; Houston 1978; Tidemann 1980; Mansergh and Huxley 1985; Cogger 1986; Losos and Greene 1988; Ward and Carter 1988). Several of these accounts emphasize the importance of nesting birds in the diet. Gogerley (1922) even speculated that some species of "low-nesting birds" including the superb lyrebird *(Menura superba),* nest during winter to avoid predation by the "... Gohanna *(Varanus varius)*". Vestjens (1977) examined the stomach contents of 18 *V. varius* from north-western New South Wales, but did not quantify his results. He identified prey including one species of bird, egg shell of one unidentified species of bird, three species of introduced mammals, tortoise eggs, and seven groups of arthropods. Vestjens (1977) further observed 10 acts of predation by *V. varius* on eggs or chicks of five species of birds.

During a study of the thermal ecology of *V. varius* (Weavers 1983), I collected scats and regurgitated stomach contents which were easily induced by the normal handling of *V. varius.* Therefore, no stomach flushing technique (e.g. Legler and Sullivan, 1979) was used. Several *V. varius* were caught while they were feeding on carcasses.

Regurgitated remnants of sheep carcasses used as bait for *V. varius* are not included in the present analysis. These bait remnants were readily distinguished as there were no other sheep in the two study areas (Bendethera and Mallacoota). However, carrion may be otherwise under-represented in scats because, unless the animal has ingested fur, little identifiable material is present after digestion of carrion.

I collected stomach contents or scats from 52 of the *V. varius* that I trapped and four samples from specimens at the Australian Museum. Of these, 50 samples yielded identifiable material; 35 from animals caught at Bendethera (35.958 S, 149.744 E) in the Deua National Park, New South Wales, 10 from animals caught near Mallacoota (37.537 S, 148.685 E) in the Croajingolong National Park, Victoria, and five from animals caught at other locations (Bathurst, Inverell, Menindee, NSW; Echuca, Vic.) A "sample" represented all the material from one individual lace monitor, and in a few instances included combined material from scats and stomach contents. Because the sample size was relatively modest, I confined analysis to simply identifying the presence of each prey item. I did not consider the results from stomach contents separately to those from scats.

The 50 samples were from *V. varius* ranging in size from 335 mm to 735 mm (snout-vent lengths) and live weights from about 750 g to 9.8 kg. As field identification of the sex of *V. varius* was inconclusive (Weavers 1983), analysis of dietary preference by sex was not attempted. Remnants of fur were cross-sectioned on stainless steel slides and identified according to the method of Brunner and Coman (1974).

Arthropods were present in 56% of the lace monitors that provided samples, macropods in 32%, rabbits *(Oryctolagus cuniculus)* in 28%, birds in 16% and reptiles or reptile eggs in 12% (Table 1). One sample contained feathers of a juvenile bird. Remains of exotic mammals were identified in 38% of the samples, native mammal remains were in 36%, and all mammals combined were represented in 78% of samples. In several samples exotic mammals were present together with native mammals, but in 8% of the samples the species of mammals could not be determined. At least 38% of the samples contained carrion (estimate based on the size of the prey species). Cat *(Felis cattus)* was the only species of mammal, exotic or native , that I observed at Bendethera that did not appear in the dietary samples from the site (Table 1). However, two species of glider (*Petauroides volans* and *Petaurus breviceps*) that I did not observe, did turn up in dietary samples (Table 1).

Table 1. Percentage of *Varanus varius* with the following food items in their diet.

	Food item	Percentage occurrence of each item in sample from: Bendethera (N=35)	All sites (N=51)
Mammalia	*Macropus giganteus*	14	16
	M. rufogriseus	6	4
	Wallabia bicolor	11	12
	Petauroides volans	3	4
	Petaurus breviceps	3	2
	Trichosurus sp.	3	2
	Isoodon obesulus	0	2
	Felis catus	0	2
	Vulpes vulpes	3	2
	Oryctolagus cuniculus	31	28
	Bos taurus	3	2
	Equus caballus	11	8
	Rattus sp.	6	4
Unidentified mammalian bone		0	6
Aves	*Menura superba**	3	2
	*Cinclosoma punctatum**	0	4
	Pardalotus punctatus	0	2
	Strepera graculina (juvenile)	3	2
Unidentified adult birds		6	6
Reptilia	Scincidae	3	2
	Agamidae	9	6
	Varanus varius eggs	3	2
	Ophidia	3	2
Teleostei		0	2
Arthropoda	Orthoptera	17	14
	Diptera	6	8
	Coleoptera	9	8
	Lepidoptera	23	22
	Mantodea	3	2
	Araneae	11	8
Human garbage		0	6

*tentative identification only.

Clearly, introduced mammals are now a major part of the diet of *V. varius* in the study areas. However, it should not be assumed automatically that the introduction of exotic mammals to south-eastern Australia has been of net benefit to *V. varius.* Certainly some of them (e.g. cattle, horses, rabbits and probably sheep) have become food for the lace monitor, but the provision of grazing land for these exotic animals has dramatically reduced the mature forest available in south-eastern Australia for *V. varius* and its native prey. As well as this, there has been the introduction of other exotic mammals (such as dogs, cats and foxes) which almost certainly prey on smaller *V. varius.* Again it is not possible to say whether overall predation on smaller *V. varius* is now greater or less than in the ecosystems of eastern Australia prior to European settlement.

The dietary results for *V. varius* differ from those recorded for *V. rosenbergi* from a similar latitude. At Kangaroo Island, South Australia (35°87′S, 136°70′E) King and Green (1979) found invertebrates in 89.3% of stomachs from *V. rosenbergi,* reptiles in 53.2%, mammals in 27.6%, and birds in 14.9%. While the types of food taken by the two species of monitor lizards are similar, the frequencies are quite distinct. Reptilian and invertebrate prey species are more common in the diet of *V. rosenbergi* than in that of *V. varius.* This may simply reflect the relative abundance of the prey species at the two locations rather than selectivity by each species of varanid. Shine (1986) and Losos and Greene (1988) suggest that varanids opportunistically exploit the local conditions and that even different populations of the one species may show intraspecific variation in diet according to local abundance of certain prey species. However, varanids can be quite selective in their diet; sympatric varanid species may utilize that habitat differently and hence show marked interspecific variation in their diet (Shine 1986; Losos and Greene 1988). Without detailed comparative information about the habitat or prey availability for *V. rosenbergi* and *V. varius* I could not determine whether their dietary dissimilarities are caused by habitat and food availabilities, by predator-prey size effects, by predator "preferences", or by a combination of all these factors.

A cluster sorting (Belbin pers. comm.) of prey items, predator size and date of capture was performed on the data from *V. varius,* but this showed no significant aggregations or links between any of these factors. No more

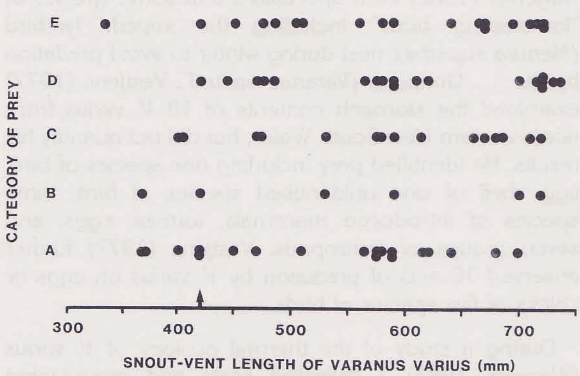

Fig. 1. Category of prey taken by Varanus varius *of a range of snout-vent lengths. Prey generally increases in size from category A to E. Prey category A=arthropod; B=skink,* V. varius *egg, vertebrate bone, human garbage; C= agamid (probably eastern water dragon), bird, rat, fish, sugar glider; D=fox, cat, brushtail possum, rabbit, greater glider, southern brown bandicoot, snake; E=cattle, horse, eastern grey kangaroo, red-necked wallaby, swamp wallaby.* Varanus varius *apparently reach sexual maturity at snout-vent length of about 420 mm (arrow) (D. Carter pers. comm.).*

than three of the same food items were found coincidentally in more than three lace monitors. No seasonal preferences for any food item were apparent. I then specifically examined whether the size of the prey taken was correlated with the size of the *V. varius* taking it. I grouped the prey species into five categories, increasing in size from category A to category E, and compared the category of prey with the snout-vent length of the *V. varius* which had eaten it. There was no apparent relationship (Fig. 1). The very smallest *V. varius* had dined on grey kangaroo *(Macropus giganteus)* while large lace monitors (up to 700 mm SVL) were recorded taking grubs (Lepidoptera) as well as larger items. In general, many types of large food items (e.g. rabbits, adult birds, macropod carrion) and small food items (e.g. arthropods) are all taken by *V. varius* of a wide range of snout-vent lengths.

Although only 50 lizards were successfully sampled, the analysis does confirm that adult *V. varius* are opportunistic carnivores, that take a wide size-range and variety of food. Varanids have a kinetic skull (Rieppel 1979) which permits tham to swallow large prey whole. I saw a 1.2 kg *V. varius* disgorge the intact and relatively undamaged carcass of a 500 g rabbit, equivalent to 42% of the predator's mass.

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